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By J. C. Franklin, P. E. Barr, K. D. Weverstad, and C. T. Sheeran

UNITED STATES DEPARTMENT OF THE INTERIOR

(United States, Bureau of Mines)

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ILLUSTRATIONS

UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

ac	alternating current	min	minute
amp	ampere	mm	millimeter
dc	direct current	sec	second
Hz	hertz	v	volt
hr	hour	WL	working level
lpm	liter per minute		

ALARM SYSTEM FOR RADIATION WORKING LEVEL, FAN OPERATION, AND AIR DOOR POSITION

By J. C. Franklin,[1] P. E. Barr,[2] K. D. Weverstad,[3] and C. T. Sheeran[4]

ABSTRACT

A 32-channel continuous monitoring system has been developed to monitor radiation working level (WL), fan operation, and air door position. The system consists of a surface receiver unit and an underground transmitter that is connected to the various monitors. A continuous WL monitor used with the system can generate alarms at two different WL readings. One of these levels is variable from 0.00 to 0.99 WL and generates an alarm on the surface receiver. The other level, fixed at 1.0 WL, generates an underground alarm in the vicinity of the monitor.

The detectors for fan operation and air door position work on the principle of a completed circuit to the underground transmitter (multiplexer). When the circuit is broken, as is the case when a fan is off or an air door is open, an alarm is generated at the surface receiver. This alarm remains in effect until the circuit is completed, signifying the fan has been turned on or the air door has been closed.

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INTRODUCTION

Exposure to decay products of radon presents a serious health hazard for underground personnel in uranium mines. The uranium mining industry presently uses grab sampling techniques, including the Kusnetz method and instant working level meters (IWLM's), for measuring personnel exposure. Holub (5)[5] shows that these measurements are accurate when used properly; however, it has been shown by Franklin (2-3) that the concentration of radon and radon-daughters is constantly changing. Because of the continual variation in the concentration, a system is needed that will alert the ventilation engineer before critical levels are reached.

The Bureau of Mines has developed a system that interfaces to continuous WL monitors and will generate both surface and underground alarms. A surface alarm is sounded when the radiation level has exceeded a preset WL limit, variable from 0.00 to 0.99 WL. An underground alarm is also generated when 1.0 WL has been reached.

Detectors have also been developed for the system that may be used to monitor the power to fans and the positions of air doors. These detectors will generate surface alarms when fans are off or when air doors are open.

ALARM SYSTEM

The basic system components include a surface alarm receiver, an underground alarm transmitter, and various detectors and monitors. The detectors and monitors will be discussed in a separate section. Current system hardware is capable of handling input from 32 underground stations. Signals from these stations are fed through individual cables to the transmitter. The transmitter multiplexes this information to the surface receiver through a single cable.

Surface Alarm Receiver

The alarm status of each channel may be monitored, both visually and audibly, by the surface alarm receiver shown in figure 1. As each channel is sampled, its green indicator light will briefly extinguish. If there is not an alarm present on that channel, no further change will be observed. However, if that channel is in an alarm state, its respective red indicator will light and an audio tone will generated unless audio alerts have been previously disabled for that channel. Separate red and green indicators are used so the operator can verify normal alarm scanning in the absence of any alarms, and to provide a positive alert in the unlikely event of an indicator (LED) failure. This indicator operation is also backed up by an alarm summary signal light that will indicate an alarm on any channel. The red light and audio tone will only last for that channel's sample time slot (approximately one-eighth of a second). Not only does this method of alarm display attract attention, it quickly identifies the occurrence of simultaneous alarms on several channels, owing to the length and pattern of alarm signals.

Once the alarm is received, the operator acknowledges each by switching the audio for each channel in alarm to an off-state. This gives the operator an indication of alarm status by light and switch position. Even if all power is lost to the receiver, the most recently updated status of each detector station is available by observing the audio switch for each channel. Once an alarm is received and acknowledged, the operator can take corrective action by mine phone or by dispatching ventilation personnel to the problem areas.

All detectors and monitors are designed to provide a positive, fail-safe

[5]Underlined numbers in parentheses refer to items in the list of references at the end of this report.

FIGURE 1. - Surface alarm receiver.

indication of normal operation. A high WL reading, an electronic malfunction, a cut or shorted telemetry wire to the transmitter, or loss of power will cause an alarm on the surface alarm receiver. Should power be lost at the underground transmitter, all alarm sequencing would cease and the receiver would maintain an alarm indication on channel 0 until power is restored. The receiver also has a clock-synchronous activity indicator and a test switch that will activate each channel's alarm indicators, both visual and audio. A remote audiovisual alarm station may be added to alert additional personnel to alarm conditions in the mine.

Underground Alarm Transmitter

Current system hardware allows up to 32 individual stations to terminate at an underground central-alarm transmitter unit. From this location, a single telemetry cable is routed to the surface alarm receiver. Figure 2 shows the block diagram of both the transmitter and receiver. This cable is a dual shielded-pair conductor that carries status signals from each station by means of time-division multiplexing techniques. The scan cycle time is 4 sec for all 32 channels.

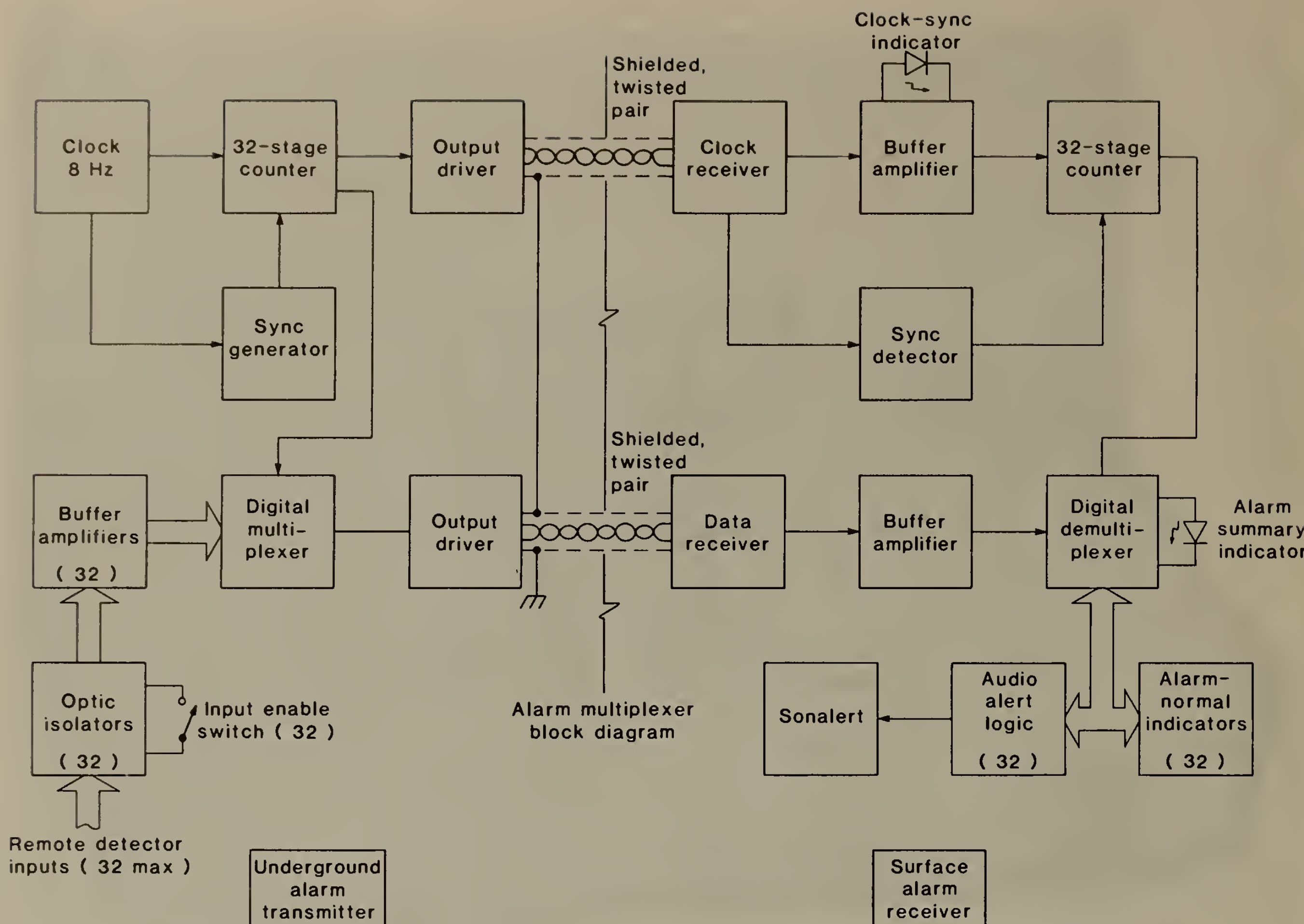

FIGURE 2. - Block diagram of alarm transmitter and receiver.

Since monitors or detectors can be located in widely separated areas and served by different power stations, electrical isolation of the unit is of utmost importance. Therefore, each signal, as it arrives at the transmitter, is terminated at the input of an optical isolator circuit. As its name implies, the signal is passed from input to output in the form of light. In the optoisolator, a light-emitting diode (LED) is optically coupled to a photodiode. When the LED is activated by the monitor or detector or other alarm interface (fan, pump, etc.), the photodiode conducts and passes this logic state onto other multiplexing circuitry. In this manner, all 32 inputs are isolated from the transmitter and from one another, preventing ground-loop voltages and unstable operation due to common mode currents.

Each optical isolator output can be individually enabled or disabled, thus allowing for maximum flexibility in grouping of signals for a system with less than 32 inputs. Each signal then passes through an amplifier with special noise-reduction characteristics to further refine logic states. These inverted signals then terminate in one of the four, eight-input multiplexer circuits.

All that remains is to sample each signal in a prescribed sequence and "tag" each one as a unique channel. An 8-Hz clock in the transmitter is used to sequentially switch each of the 32 data

inputs (0-31) onto a data output line to the surface alarm receiver. This same clock signal is sent to the receiver station to control the demultiplexing circuitry. Each data input is identified by its respective time slot in the clock pulse-train. However, to attain accurate data transfer, the time-slot counters at each station (underground transmitter and surface receiver) must be in step. This is accomplished by making one timing slot unique in comparison to all others. Channel 0 is twice the width of any other channel for detection at the receiver. This makes the system a synchronous data multiplexer.

Both clock and data signals are routed simultaneously to the surface receiver. The clock signal drives a 32-stage counter as in the transmitter. This clock signal is also monitored by a missing pulse detection circuit. When this circuit "recognizes" channel 0's extra width, it resets the receiver's clock to zero and outputs that time slot. Each successive clock cycle will advance the receiver's time-slot counter, and the information on the data line from the transmitter will be synchronously decoded for each respective channel.

MONITORS AND DETECTORS

The alarm system was designed to operate with continuous WL monitors and detectors for alarming when the circuit is broken. Other monitors with an analog output could be used to alarm when the output drops below a set voltage.

The continuous WL monitors are designed so they can be used as a stand-alone monitor in small mines or as a part of the alarm system. As a stand-alone unit, the continuous WL monitor would just alarm for 1 WL or greater at the monitor itself.

Working Level Monitor

The detectors used in the working level monitors are Geiger-Mueller (GM) tubes. Nuclear disintegrations resulting in beta particle emissions will cause a detectable pulse output from the GM tube. Droullard (1) reports a complete description for the operation of the GM tube detector. These detectors have been in use for several years in various mines with good results. The monitor described in this report, although similar to that described by Droullard, has been interfaced to a microcomputer to convert raw count into WL's, display that value on the monitor itself, and energize the alarms when the set values are exceeded. Two alarms are possible from each monitor used with the system, one at the surface receiver, and the other at the monitor itself. The surface alarm limit is variable and its setting can be determined by company policy, while the underground alarm limit is fixed at 1.0 WL. The monitor is shown in figure 3. The housing is constructed of stainless steel with a rubber gasket around the lid to seal out moisture. The beta detector assembly is mounted on the lid for easy access in changing the 47-mm filter.

Inside the housing are the power supplies for the GM tube and the microcomputer, an airflow regulator, an airflow meter, a discriminator pulse-shaping card, and a data switchboard. This board is used for setting detector background, sample time, calibration factor, and variable alarm point setting values for retention during a power loss. A SYM-1[6] microcomputer completes the major portion of the monitor components. There is a switch for shutting off the pump when background measurements are being made and a 2-amp fuse for the complete system.

Figure 4 shows the layout of the data switchboard. The top row (six switches)

[6]Reference to specific equipment is made for identification only and does not imply endorsement by the Bureau of Mines.

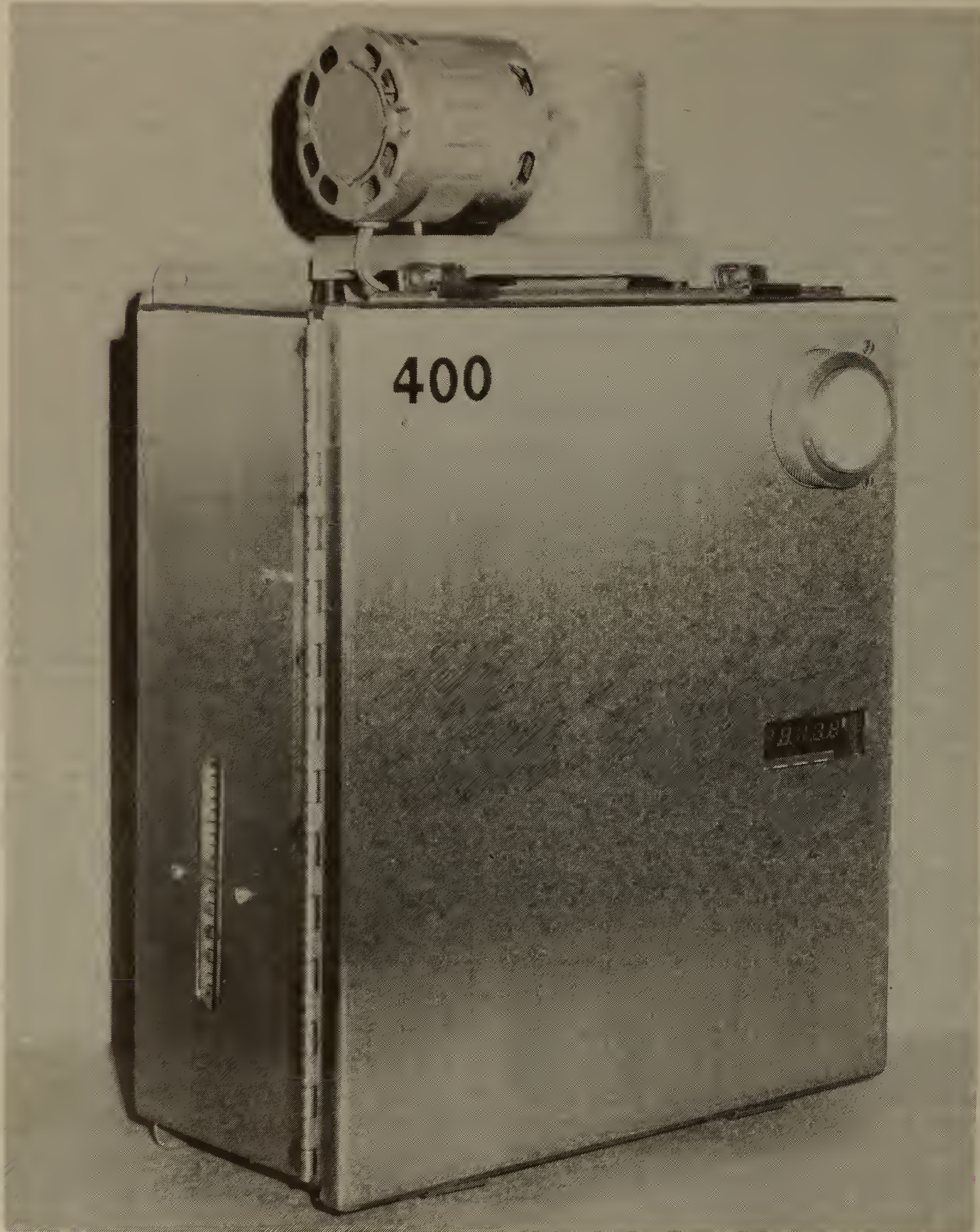

FIGURE 3. - Continuous working level area monitor.

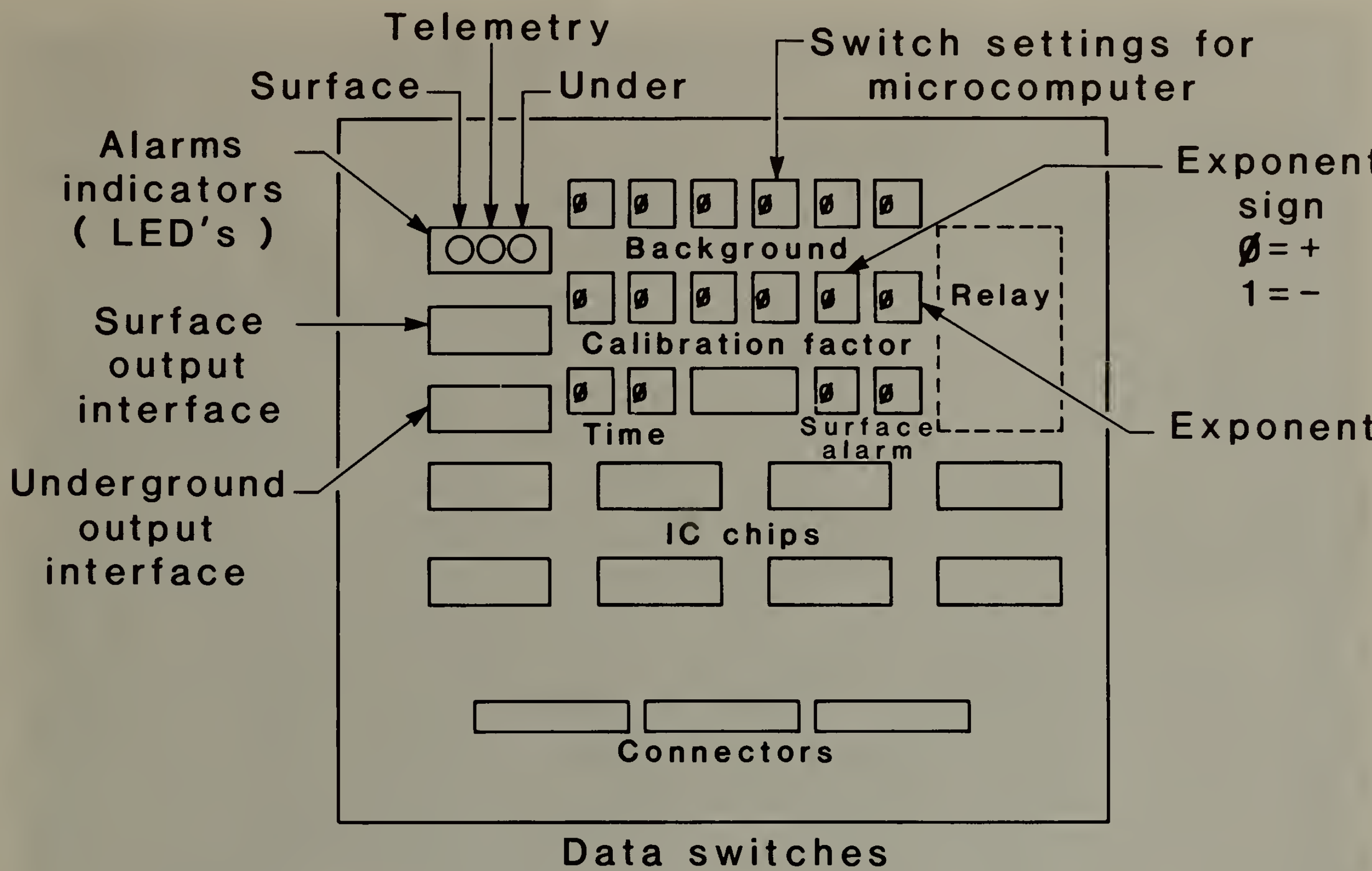

FIGURE 4. - Data switchboard layout.

is used for setting the gamma background. Because background is dependent on location, this setting must be adjusted each time the monitor is installed. The procedure for taking backgrounds will be described in a later section of this paper. The second row (six switches) is used for setting the monitor calibration factor (C.F.).

This calibration factor takes into account the counting characteristics of the monitor, and is also influenced by the airflow rate (usually 1.0 lpm). If the C.F. has previously been determined for a different airflow rate than what is desired, the new C.F. can be calculated by simply dividing the old factor by the new airflow rate. This is represented by the following equation:

$$\frac{\text{C.F. for old airflow rate}}{\text{new airflow rate}} = \text{C.F. (new)}. \qquad (1)$$

The third row of switches is used to set time interval (left two switches) and surface alarm limit (right two switches). The time interval can be set from 1 to 99 min, while the surface alarm can be set from 0.01 to 0.99 WL.

Figure 5 shows how the switches would be set if the following parameters were used:

Background	9387
Calibration factor	6.47×10^{-4}
Time	5 min
Surface alarm	0.50

Microcomputer

The microcomputer (fig. 6) is the SYM-1 single-board computer. It is an 8-bit, 6502 microprocessor-based system with input-output interfaces, random access memory (RAM), read-only memory/erasable programable read-only memory (ROM/EPROM), clock generator, RS-232C interface, operator keyboard, and a six-digit output

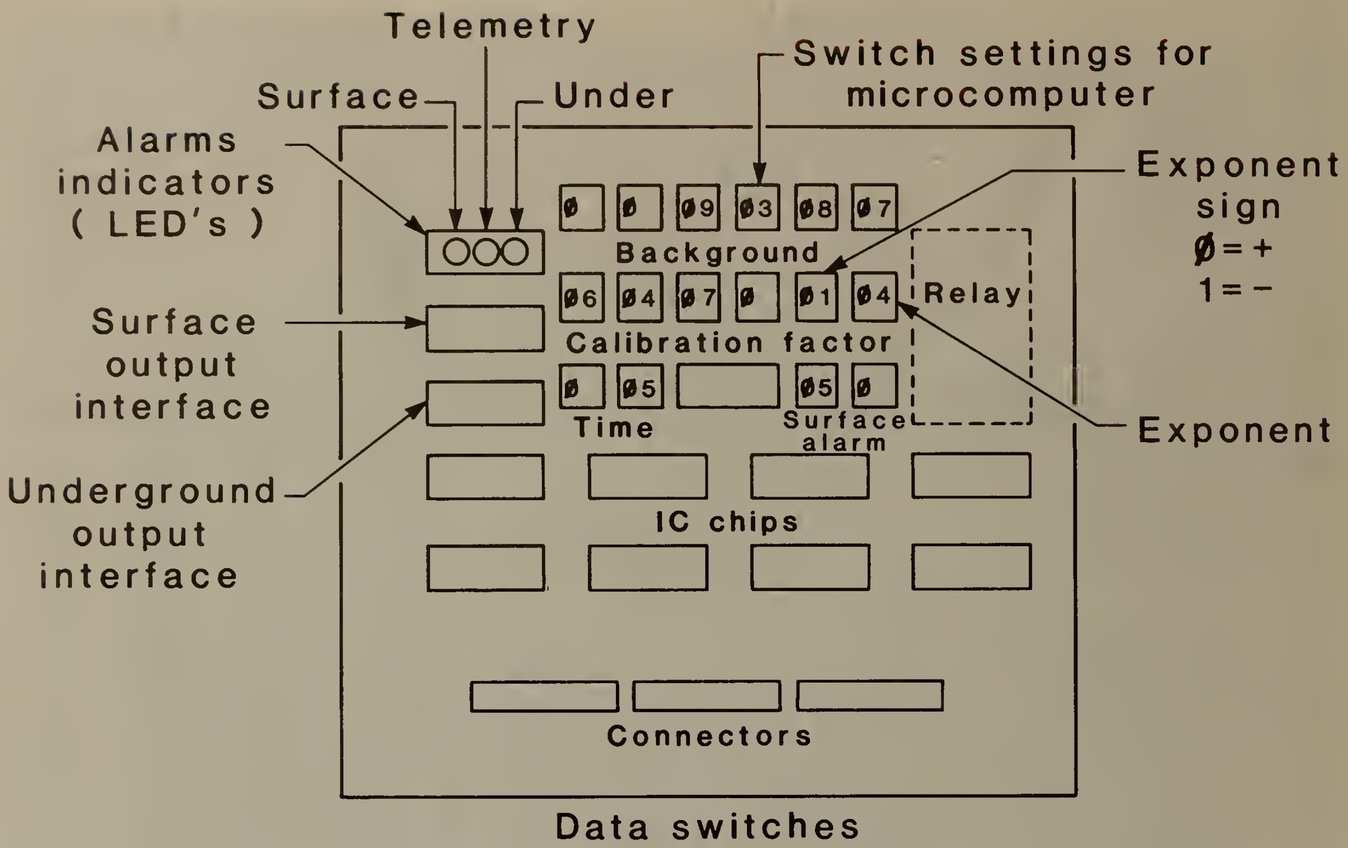

FIGURE 5. - Data switchboard with example settings.

display. Software and descriptions of the microprocessor are described by Franklin (4) and Shaw (6).

Upon applying power to the monitor, a power-on reset signal is generated that resets all input-output interfaces, including timers and counters, in the microprocessor. The monitor operating parameters are read from the data switches and stored, and all alarm flags are cleared. There are five diagnostics that should be run to ensure proper operation of the microcomputer. When the reset key is pressed, the operator has 10 sec to select the diagnostic to be performed. The diagnostics are as follows:

Reset A: Sequences the alarm conditions in 10-sec intervals. If the surface alarm switches are set above 0.30 WL, both the yellow (surface) and red (underground) LED lights will come on together. If set below this level, each will come on separately--surface followed by underground. These alarms will clear in reverse order. The display will spell out the alarm states as they cycle.

Reset B: Displays background measurements for the GM tube.

Reset C: Performs diagnostics for math routines by inserting preset count, background, calibration factor, and time into calculations. A display of 77.77 WL indicates the math routines are operating normally.

Reset D: Reads the data switches and displays each value for verification.

Reset E: Starts timer that will read up to 99 min and 59 sec.

Upon completion of checks, push reset; after 10 sec, with no further keyboard entry, the main program locks in. The mine air monitoring cycle for WL then begins and repeats according to the sample time selected.

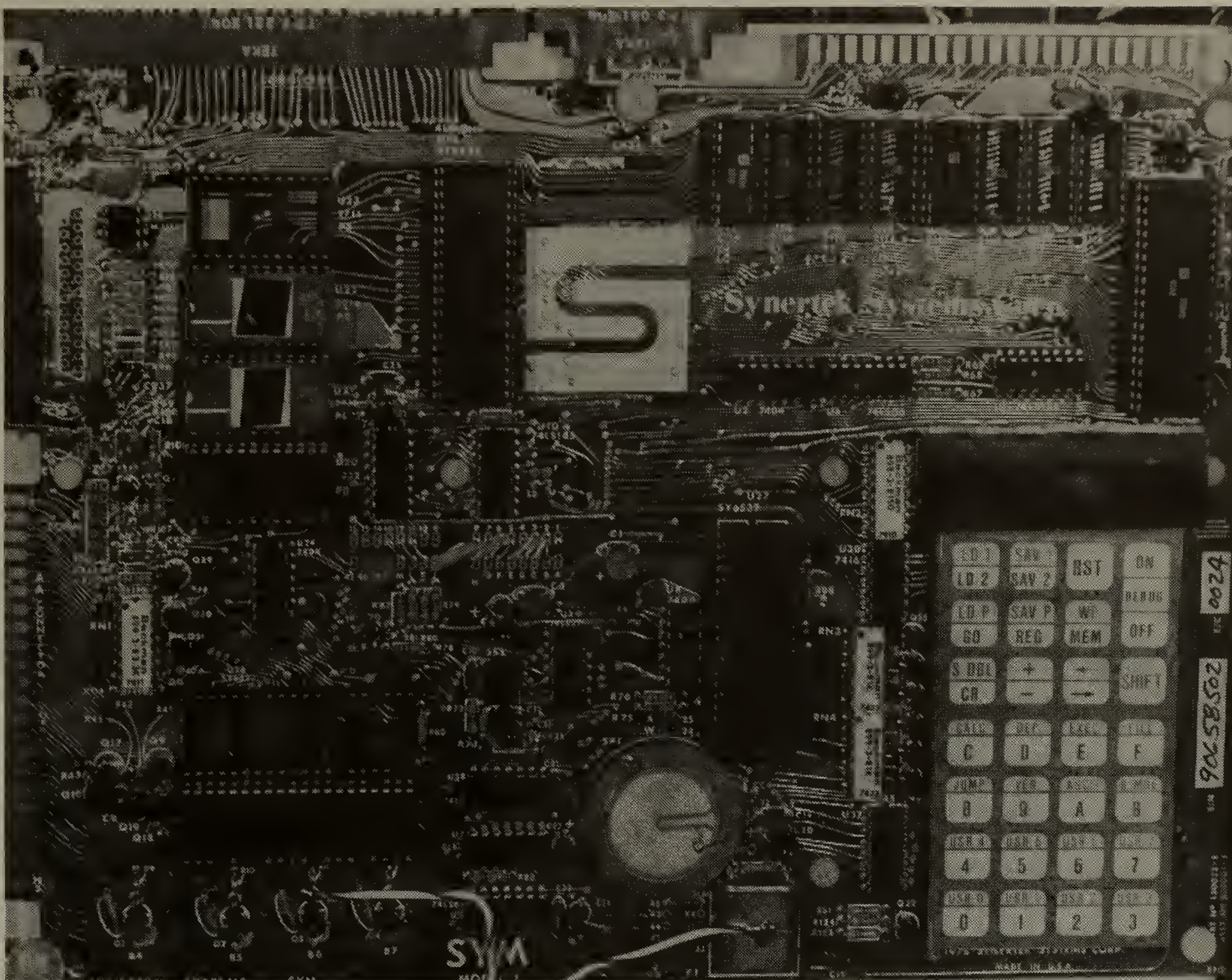

FIGURE 6. - SYM-1 microcomputer.

Installation Suggestions

Site selection for each monitor should be carefully made. The monitor should be placed in a working area such that air sampling will be representative of the entire work area. To determine a good site, WL samples should be taken in several locations in the stope or heading to determine an average concentration. Procedures for taking these samples will be addressed in the section discussing equipment calibration.

Once the general area has been located, several other factors must be considered. First, the monitor should be installed so that it will not be damaged by personnel, vehicles, slushing cables, or other equipment. The ideal location would be to suspend the monitor midpoint in the drift facing into air and away from intersections. If it is not possible to suspend the monitor in the center of the drift, it can be installed on the rib.

Extreme care should be taken to ensure the monitor is not in a direct line of blasting or placed under loose rocks. Also, it is important to ensure that the location is safe for personnel to stand in while checking the equipment.

This monitor requires 120-vac, 2.0-amp electrical power. Power is connected to the monitor through the three-pin

connector located on the left side of the housing. Power should only be applied when the monitor is ready for calibration and after careful inspection for loose integrated-circuit chips, connectors, electrical wires, or bolts.

The five-pin connector, located on the bottom-right side of the housing, sends the alarm signal to the surface and underground alarm indicators. The connector is wired so that pins A and B are the signal wires going to the multiplexer transmitter. Pins C and D are used to connect the relay switch in the underground alarm detector to a local alarm. Pin E is for grounding purposes.

Calibration Procedure

Depending upon the number of monitors to be used, there are two ways to calibrate them. One way, using only a few monitors, would be the individual calibration of each monitor in its final location. With a larger number of monitors, group calibration in an undisturbed drift with a relatively constant WL would be more time-effective. The second method is described below. In this case, place the monitors facing the airstream and calibrate them all at the same time.

Either the Kusnetz method or an instant working level meter (IWLM) may be used to determine WL for monitor calibration (step 12). Normally, the WL monitor would be calibrated with whatever method the mine currently uses.

To determine the calibration factor for the continuous WL monitor, a step-by-step procedure is as follows:

1. Hang all WL monitors at the same level in an undisturbed drift with a radon-daughter concentration of approximately 0.3 to 0.5 WL.

2. Make sure that all pumps are shut off before connecting power.

3. Place a new 47-mm filter in each WL monitor.

4. Turn power on.

5. Set the sample time into the data switches (two lower left-hand switches). Normally a 5-min count is used.

6. Push "Reset" "B" on the microcomputer keyboard. Do this to each monitor at 10-sec intervals. This will start the WL monitors taking background data. Figure 7 is an example to use for recording data during calibration. These data should be kept for future reference.

7. Take *at least* five 5-min counts. Record the counts, then total and average for each WL monitor. This is the WL monitor background.

8. Take the average backgrounds just calculated and set them on the data switches in each WL monitor. (The background data switches are the top row of switches.)

9. Turn on the pump.

10. Hook a section of tygon tubing between the exhaust of the WL monitor and a volumetric-flow measuring instrument. Time the flow with a stopwatch for 1 min to determine actual flow rate. If flow is not 1.0 lpm, then adjust the flow and take several more readings to be sure it is accurate and holding steady. Do this to each WL monitor to be calibrated.

11. Actual calibration may now be started. Place a new filter in each WL monitor and let run for at least 3 hr before taking the first count.

12. Push "Reset" "B" on the microcomputer keyboard. Do this to each monitor at 10-sec intervals. This will start the WL monitors taking data. At the same time, mine personnel should start taking a sample with their instrument and recording the WL that they obtain. Corresponding samples must be taken at the same time with both the mine instrument and the monitors.

DATE ____________________

LOCATION ____________________

OPERATOR ____________________

DETECTOR NO. ____________ FLOW ____________ BACKGROUND ____________

	(1) Count	(2) Count-BG	(3) $\frac{\text{Count-BG}}{\text{Time}}$	(4) WL	Source
AV					

FIGURE 7. - Calibration data sheet.

13. Take *at least* five 5-min counts on each monitor. Record the counts, then total and average for each WL monitor. This value is the Raw Count.

14. The WL measurements taken by mine personnel during the same time-intervals should now be totaled and averaged.

15. The calibration factor for each WL monitor can now be calculated by using the averaged data in the following equation:

$$\frac{(\text{WL})\ (\text{sample time})}{\text{Raw count} - \text{background}} = \text{C.F.} \qquad (2)$$

The WL above is that obtained by Kusnetz or IWLM methods. The value obtained must be expressed in scientific notation before being set in the data switches. An example of this calculation is presented at the end of these instructions.

16. Take the calibration factor and set it in the second row of data switches in the WL monitor. NOTE: The second from the right data switch designates whether your power 10 number is a positive or negative number. The switch set in the "0" position indicates a positive power, while "1" indicates a negative power. The far-right switch indicates the power of 10. The data switchboard has a decimal hard-wired in between the first and second switch from the left.

17. Obtain source counts for each monitor by placing a known (cesium-137) source in the filter mount and recording at least five samples.

18. Take the WL monitors from the calibration area and hook them up in their respective locations within the mine.

19. Discuss with mine personnel as to what WL limit is desired for the variable setpoint surface alarm. Approximately 0.7 WL is recommended, but it may be anything under 1.0 WL. Set this figure into the two lower right-hand data switches.

20. Replace the filter in the WL monitor. Before taking a new background count, make sure that at least 3 hr have passed since the pump was shut off during calibration. Push "Reset" "B" on the microcomputer keyboard. Take at least five 5-min counts. Record the counts, then total and average them for the new background. Set this new background into the WL monitor through the use of the data switches.

21. Set the airflow to the desired level using the volumetric flowmeter. If any flow other than 1.0 lpm is used, the calibration factor has to be corrected for the new flow rate. Make a mark with a grease pencil on the flowmeter, indicating the level that the flow ball is to reach. (This should be checked at least weekly during the test to ensure proper air intake.)

22. Run the diagnostic subroutine test programs that have previously been discussed.

23. Push "Reset" to monitor the working level in this particular area.

As an example for calculating calibration factor, the following data are used:

Raw Count:	8593
Background:	154
Time:	5.0 min
Flow:	1.0 lpm
WL:	0.43

$$\frac{\text{Raw count - background}}{\text{Time}} = X \qquad (3)$$

$$\frac{8595 - 154}{5.0} = 1687.8.$$

$$\frac{0.43}{1687.8} = 0.0002547695 = 2.55 \times 10^{-4}. \qquad (4)$$

Equation 3 will convert net count into counts per minute, while equation 4 will convert counts per minute into WL per count at the 1.0-lpm flow rate. This is the calibration factor. If the flow rate has been changed after the monitor has been relocated, obtain the new C.F. by dividing the original C.F. by the new flow rate (eq. 1). Set this new C.F. into the data switches.

Maintenance

The 47-mm filter should be changed at least once a week and more often if the filter becomes plugged with diesel smoke and dust, or saturated with moisture from humidity. When replacing this filter, extreme care should be used to prevent damage to the backup screen (do not use a knife or screwdriver blade to remove the filter). The flowmeter should be read at the same time to ensure that the desired air volume is being taken. If not, adjust the flow with the flow regulator and recheck about 1 hr later.

Once a month, the cesium-137 source should be counted on each WL monitor with the pump off and a clean filter placed in the holder. After counting the source, recheck the background with the pump off and the source removed. The airflow should also be recalibrated monthly to ensure proper flow.

The diagnostic routines should also be checked monthly to ensure proper operation of the microcomputer and to verify that the data switches have not been changed. Visual inspection of all signal cables should be made when walking through the drifts.

Fan Shutdown-Air Door Position Detectors

Although the alarm system was primarily designed to alert for high radiation levels, it can also be used with special detectors to monitor fan shutdowns and air door positions. These factors are important in controlling the underground radiation hazard.

If the underground fans are shut off, the fresh air to the face will stop or be greatly reduced, eventually causing a WL alarm condition. Therefore, a unit was designed to detect loss of power to the fan (fig. 8).

When ac power is lost or shut off to the fan, an alarm condition will result on the receiver located on the surface. This alarm system works on a closed-circuit principle where a completed circuit is necessary for a no-alarm condition. An alarm will occur if any part of the circuit fails that is needed to carry the signal to the underground alarm transmitter. A red-light alarm on the

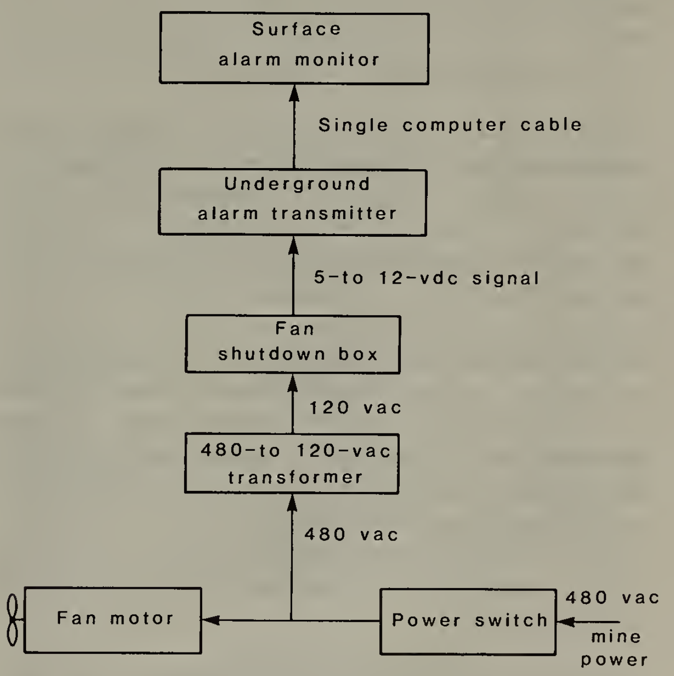

FIGURE 8. - Block diagram for monitoring power loss to underground fans.

surface receiver will be displayed showing the channel number corresponding to the fan location.

In figure 8, it can be seen that the circuit to the detector obtains power from the same 480 vac that supplies the fan motor. By tapping off at a point between the fan motor and power switch, both ac power monitoring and switch monitoring are possible. In the event of an off-switch, power failure in the mine, electronic problem, or a cut cable, an alarm will result.

Using the same switched 480 vac to the fan motor, a stepdown transformer brings the voltage down to a usable 120 vac for the electronics in the fan shutdown detector. A power supply within the detector transforms the 120 vac into 9 vdc needed for the electronic circuit. This dependent electronic circuit then drives the signal (necessary for a no-alarm state) to one channel in the transmitter. The fan shutdown detector can easily be modified to monitor air door position by inserting a microswitch into the same electronic circuit. In figure 8, a microswitch is placed on or at the door so that the switch will break the circuit when the door is opened. This broken circuit will result in an alarm being sent to the surface receiver.

SYSTEM TROUBLESHOOTING

System troubleshooting can be simplified by using the LED indicators present on each device to diagnose possible problems. There are two vital links in the system that will be treated separately in the troubleshooting. These are the receiver-to-transmitter connection and the connection between the transmitter and the monitors or detectors.

Receiver to Transmitter

All data concerning the underground stations are communicated through a single cable from the transmitter. Because of this, this connection is vital in the fail-safe, signal-dependent alarm system.

The transmitter generates a clock signal with which the surface receiver has to synchronize before sequencing of the channels will begin. A lockup situation on channel 0 of the receiver may be caused by the following:

1. Transmitter turned off or power disconnected.

2. Cut cable, power loss, or bad splicing connection.

An alarm check switch on the receiver will check the sequencing of the LED's and may also be used to check for any that have burned out. A backup LED labeled "ALARM" (red color) allows any burned-out LED to be monitored in the sequencing channels. Also, a clock-synchronized LED flashes to indicate the incoming clock signal from the transmitter. Through the use of these indicators, various problems can be determined from the surface if the system fails or if a true alarm condition is present.

Underground Transmitter

The transmitter's front panel contains the following items:

1. Green LED (monitors 5-v power supply needed for electronics).

2. Yellow LED (flashes to indicate unit is sending out a clock signal to the surface receiver).

3. Red LED (comes on when activated channels are in alarm status--may be produced by unhooked connectors, broken signal cables, power loss, or an alarm signal from the monitors or detectors).

4. Red neon lamp (indicates 120 vac power is on).

Green LED	Red LED	Yellow LED	Red neon	Explanation
ON...............	Flashing	Flashing	ON	Normal.
OFF..............	Flashing	Flashing	ON	Green LED burned out.
OFF..............	OFF	OFF	ON	([1])

[1]Check the fuse and connections to and from the 5-v power supply, also check the 5 vdc out of the power supply to the electronics. If all connections are secure and there is no signal from the power supply, it may be defective and need replacement.

5. Keyed switch (on-off for 120 vac to transmitter).

6. Three-pin connector (120-vac power input connection).

7. Five-pin connector (signal cable connection to surface receiver).

8. Elapsed time counter (displays hours of use).

The key troubleshooting areas to look for in the underground transmitter are the LED's and the neon lamp. Conditions that may occur are listed in the above tabulation.

<u>Transmitter to Monitors or Detectors</u>

Whenever a monitor or detector is connected to the underground alarm transmitter, certain procedures will enhance installation and minimize problems. Cable should be installed in locations where minimal damage will occur, such as on the back or behind vent bags. They should not be attached to power, compressed air, or water lines. Butt splicing should be correctly performed and used with water-protective tape. Keep detectors and cables out of water and secured effectively to prevent them from falling.

Once the signal cable is connected to the surface alarm receiver and the underground alarm transmitter, a signal cable from a monitor or detector can be attached to the appropriate channel connection on the back of the underground alarm transmitter. The back panel of the unit has 32 connectors corresponding to channels labeled from 0 to 31. For example, if channel 0 was connected to a signal cable, the other end would be connected to a monitor or detector in a selected location in the mine. After a monitor has been installed with ac power on, signal cable connection can then be made.

The working level monitor contains the following LED's which can be used to diagnose problems:

1. Red (on flowmeter)--flashes as pulses are processed from the GM tube through the amplifier and discriminating pulse-shaping card.

2. Green (on data switchboard)--when on, indicates communication with transmitter via the signal cable (telemetry).

3. Yellow (on data switchboard)--when on, indicates an underground alarm condition ($\geq$1.0 WL).

4. Red (on data switchboard)--when on, indicates the variable setpoint alarm limit has been exceeded and that an alarm is being sent to the surface through the underground transmitter.

Once the connection to the working level monitor has been made and the telemetry light shows a completed connection to the underground alarm transmitter, the following procedures should be performed:

1. Check filter on GM tube for cleanliness and correct installation.

2. Check various cable connections inside the monitor box for secure contact.

3. Check integrated circuits and data switch chips for contact in appropriate socket.

4. Check red (LED) light on flowmeter for a flashing, incoming count from the GM tube.

Conditions that may occur with the monitor LED's are listed in the tabulation below.

As a final check, perform the microcomputer diagnostics explained earlier in this report. When a reset "A" is activated on the computer, the alarm sequence subroutine will cycle through the alarm, no-alarm state. This alarm signal output from the computer can be monitored by the three LED's on the data switchboard. The green LED will be on during the first three periods of the cycle in which the display on the computer will show "ALA."

At the beginning of the fourth alarm cycle, the display will change to "ALA-US" to show an underground and surface alarm status. The computer at that instant puts the monitor in alarm status by turning off the green telemetry LED and turning on the yellow and red LED's, thus indicating that the underground alarm light is on and that the surface alarm is being sent from the monitor to the underground alarm transmitter. The alarm for

Red (flowmeter)	Green on data switchboard	Yellow	Red	Explanation
Flashing.......	ON	OFF	OFF	Normal operation, no WL alarms.
Flashing.......	OFF	OFF	OFF	([1])
Flashing.......	OFF	OFF	ON	Normal operation, variable setpoint alarm limit exceeded and surface alarm being generated.
Flashing.......	OFF	ON	ON	Normal operation, both alarm limits have been exceeded and both underground and surface alarms are being generated.
OFF............	-	-	-	([2])

[1]May be due to several problems including cut or unconnected cable, monitor power off, or the optoisolator for that channel in the transmitter is defective. Find out if the monitor is defective by replacing it with another unit. If the green light is still not on, the first monitor is probably all right. Check connections and cables, and also verify that there is power to the transmitter. If these check out, the optoisolator for that channel in the transmitter is probably at fault and should be replaced.

[2]GM tube, amplifier circuit, GM power supply, discriminating pulse-shaping card, or LED could be defective. Use the following procedure:

1. Perform a "Reset" "B" on the microcomputer to check for pulse input. If a normal count is displayed at the end of the count period, the LED is probably burned out.

2. In the event there is no pulse input to the microcomputer, use a voltmeter to check the output of the power supply (1,000 vdc) and check connections or replace power supply if defective.

3. Use an oscilloscope to verify pulse output from the GM tube and amplifier circuit--replace parts as necessary.

4. If all else checks out, the problem lies in the discriminating pulse-shaping card. Replace or repair as needed.

"US" will cycle four times and then return to a no-alarm state. This will continue until "reset" is pressed.

When the troubleshooting techniques unique to the working level monitor have been satisfactorily performed (power cables, alarms, telemetry checks, and a flashing red LED on the flowmeter), push "reset" on the computer and close the lid. Wait to ensure that the main program has taken over and is displaying working level readings.

The fan operation and air door position detectors both contain a single, green LED that can be used for troubleshooting. When the detectors are properly installed, the green LED should light when the signal cable from the underground transmitter is hooked up (assuming the fan is on or air door is closed). If it does not light, the LED may be burned out or power may be off to the detector. Check this by shorting across the output connector to light the LED. If this is normal, then the problem is in the connection to the underground transmitter and may be due to a cable fault or a defective optoisolator in the transmitter.

CONCLUSIONS

Through the use of this alarm system, the ventilation engineer will be able to detect when underground fans are operating, air doors are open, the WL has reached the company's shutdown level, and when 1 WL has been reached. By early detection of fan shutdown or reaching the company's desired maximum limit, the miners can be withdrawn from areas while corrective action is taken to prevent excessive radiation exposures.

The WL monitors can be used as a standalone unit in small mining operations without the use of the multiplexer transmitter and receiver. This would still alert the miners when excessive radiation levels are being approached so that corrective action can be taken.

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